CONNECTICUT RIVER BASIN ANADROMOUS FISH RESTORATION: Coordination and Technical Assistance F-100-R-33

Annual Progress Report October 1, 2015 - September 30, 2016

U.S. Fish and Wildlife Service
Connecticut River Fish and Wildlife Conservation Office
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Executive Summary

Federal Aid Project # F-100-R-33

States: Connecticut, Massachusetts, New Hampshire and Vermont

Project Title: Connecticut River Basin Anadromous Fish Restoration: Coordination and Technical Assistance

Period Covered: October 1, 2015 - September 30, 2016

This annual report provides an opportunity to organize and document, to varying degrees, all work activities conducted by the Connecticut River Fish and Wildlife Conservation Office (CTRFWCO), formerly the Connecticut River Coordinator's Office, which includes work outside of the Connecticut River basin and activities not funded by this grant.

Objectives:

- Coordinate the Connecticut River Anadromous Fish Restoration Program as a unified effort of State and Federal fishery agencies
- Provide technical assistance to the fishery agencies and other program cooperators
- Identify fishery program priorities, design and implement projects to address issues and opportunities, and develop plans
- Administer several different federal grant programs to address fish habitat, passage, management, and research projects

Accomplishments:

<u>Program Coordination</u>

- Organized two Connecticut River Atlantic Salmon Commission (CRASC) and two CRASC Technical Committee meetings
- Organized CRASC Shad Studies and River Herring subcommittee meetings
- Served as USFWS project officer for U. S. Geological Survey Conte Anadromous Fish Research Laboratory (CAFRC) – Effects of temperature and energy use on fish passage and spawning success of American Shad (2015-2017), USFWS Science Support Program
- Provided annual upstream and downstream fishway operations letters to hydropower owners and the Federal Energy Regulatory Commission (FERC)
- Coordinated river herring population assessment and restoration activities in the Connecticut River basin
- Coordinated meetings and activities of the CRASC Connecticut River Basin American Shad Management Plan update team

- Coordinated multi-agency American Shad population model meetings with NOAA Fisheries technical staff and partners

Technical Assistance

- Completed downloading and servicing of all remote water temperature loggers
- Participated in ongoing hydropower federal relicensing meetings, study report reviews, and comment/response letter development, for both FirstLight Power and TransCanada
- Installed the new 990 gallon, insulated fish transport tank and refitted on truck
- Completed the Annual Sport Fish Restoration Grant Report for FY15
- Completed additional analyses of 2011 and 2012 American shad migration study. An oral presentation "Passage performance and migratory delay of American Shad at the Holyoke Fishlifts," co-author with Ted Castro-Santos (presenter) was given at the 6th International Fish Passage Conference at UMass/Amherst, June 2016
- Data summarization and analyses (ongoing) were completed on the river herring assessment program data
- Conducted river herring population assessment surveys on 25 dates from March 30, through June 2, 2016, at seven standard sample location
- Processed in the field a total of 1,586 Blueback Herring (BBH) and 586 Alewife (ALW) captured for biological data, during spring 2016 river herring population surveys
- Processed in the laboratory a total of 730 BBH and 461 ALW, subsampled and retained from field (e.g., otolith extractions and scales) in 2016

Alewife (top) and blueback herring

- Cleaned and slide mounted scale samples from all 2016 lab processed river herring (N = 1,191)
- Obtained tissue samples from 60 Alewife (Mattabesset R) tested for fish health (viral/bacterial), by USFWS Lamar Fish Health Unit, no tested pathogens detected
- Obtained tissue samples from 60 American Shad from Holyoke Fish Lift for fish health testing (USFWS Lamar), no detected pathogens
- Served as a USFWS member to Northeast Regional Agency River Herring Team, provided updates on population assessment activities
- Served as USFWS member to the Atlantic States Marine Fisheries Commission's Shad and River Herring Technical Committee, participated in on-line meetings/activities, installed as Vice Chair
- Participated in ASMFC River Herring Monitoring Workshop and contributed to Workshop Report, available ASMFC web site: http://www.asmfc.org/uploads/file/56fc3c6dRH_DataCollectionStandardizaitionWorkshopSummary_March2016.pdf
- Captured American Eel by back-pack electrofishing to support USGS Conte Lab research on swimming performance studies
- Served as member on the USFWS Connecticut River Pilot for the Landscape Conservation Cooperative and its aquatic team
- Participated in World Fish Migration Day at Holyoke Fish Lift in May
- Provided program information and requested data to cooperators, researchers, and the public

- Provided field support to UMASS/Conte Lab, PhD student conducting research on egg and larval development of Blueback Herring
- Provided presentation to UCONN/Storrs Department of Natural Restoration on career opportunities/panel discussion
- Served as a reviewer for NOAA Fisheries SK Grant proposals and the Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes (released in May)
- Revised Office web site, provided oversight of design and materials posted
- Revised the CT River Basin Fishway Counts report and distributed 2-3 times a week in-season electronically and posted updates on the Office web site (Appendix A)
- Supervised a University of New Hampshire student intern, and four Student Conservation Interns
- Recruited and hired a Biological Trainee (Pathways-term) Biologist from UMass/Amherst
- Captured by boat electrofishing 1,010 blueback herring that were transferred to the Oxbow, Easthampton, MA
- Transferred 976 American Shad, from the Holyoke Fish Lift, to the Farmington River (CT), upstream of the Rainbow Dam
- Conducted sea lamprey nest surveys in Massachusetts in the lower Green River, Fall River (above and below removed dam), lower Sawmill River, target reaches of the Manhan River, lower Dry Brook (below 1st dam), lower Four Mile Brook, lower Whetstone Brook; in New Hampshire in the lower Ashuelot River, and in Vermont on a reach of the lower West River (VT), downstream of Townshend Dam
- Maintained adult Atlantic salmon return and stocking databases, and fish transfers databases
- Completed the cleaning, mounting and reading of nearly all (90%) back-logged scale samples of river herring
- Maintained fish passage (counts) databases, provided data as requested
- Conducted stream electrofishing surveys below first barriers in select tributaries (Massachusetts) to assess American Eel relative abundance and size structure

Backpack electrofishing

- Staff assisted in a regionally coordinated culvert assessment program in Massachusetts and New Hampshire
- Assessed juvenile production (fall) of Blueback Herring transferred to the Oxbow and sampled Wethersfield Cover (CT) for comparison of data
- Provided assistance for S. O. Conte National Wildlife Refuge Comprehensive Conservation Plan (aquatic section narratives)
- Participated in the Connecticut River Watershed Council Source to Sea clean-up with boat.

Acknowledgements

There are many people that have contributed to the work accomplished by this office in the report period. Darren Desmarais served as the sole permanent staff (biologist) for the CTRFWCO and contributed greatly to the Office's accomplishments. In May, Rebecca Gleason (new Administrative Assistant, covering three offices) was hired and is stationed at the CTRFWCO. In addition Drew Fournier (Biological Trainee) began work in May while completed his degree at UMASS/Amherst. The Student Conservation Interns in 2016 were shared under Conte Refuge administration; Will Shell, Kathleen Johnson, Forest DeCoste, and especially Madeline Freiburger (lead on fisheries), made significant contributions spring through the fall. Shelby Scarfo, a University of New Hampshire intern, volunteered for a second field season this year. Other volunteers provided valuable assistance for both field and lab activities over the year. Don Pugh has continued to support the resource agencies' efforts on hydropower relicensings and fish passage activities with his ongoing involvement in FERC related activities fish passage activities at Holyoke Dam. Katie Kennedy, The Nature Conservancy, has continued to make important contributions on FERC activities and other aquatic conservation initiatives.

Other thanks for assisting in the accomplishments over this report period go to:

State fishery agencies -

- Connecticut: Steve Gephard, Dave Ellis, Tim Wildman, Jacque Benway, and staff
- Massachusetts: Caleb Slater, Ben Gahagan, and Scott Elzey and lab staff
- New Hampshire: Matt Carpenter and Gabe Gries
- Vermont: Lael Will and Ken Cox

Federal agencies –

- USFWS: Melissa Grader, John Warner, Phil Herzig, Brett Towler, Andy French, David Perkins, Artie McCollum
- NOAA Fisheries: Bill McDavitt
- USGS Conte Lab: Ted Castro-Santos, Alex Haro, Steve McCormick, Micah Kieffer

The Anadromous Fish Program and The Connecticut River Atlantic Salmon Commission

The administration of the interjurisdictional cooperative effort to restore diadromous fish species to the Connecticut River basin is accomplished through the Connecticut River Atlantic Salmon Commission (the Commission). During the period from 1967-1983 (prior to the Commission), restoration of anadromous fish, primarily Atlantic Salmon and American Shad, on the Connecticut River was guided by the Policy Committee and the Technical Committee for Fisheries Management of the Connecticut River Basin. The importance of this formally-structured, coordinating and regulatory body to the restoration program was recognized in 1983 when Congressional consent was given to the Connecticut River Basin Atlantic Salmon

Compact, Public Law 98-138. The enabling legislation was re-authorized for another 20 years in 2002. This law, originally passed by the legislative bodies in each of the four basin states, created the Commission and conveys Congressional support to an interstate compact for the restoration of anadromous fish to the Connecticut River Basin. The Commission is comprised of ten Commissioners (Table 1) including a high-level government employee and a public sector representative appointed by the governor of the appropriate state, and the Northeast Regional Directors of both the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) also referred to as NOAA Fisheries.

The Commissioners act on policy matters and are advised on scientific and technical matters by a Technical Committee. The Technical Committee is comprised of senior staff biologists from each Commission member agency, the U.S. Forest Service (USFS), and the Massachusetts Division of Marine Fisheries (Table 2). The Technical Committee has nine subcommittees, with specific areas of responsibility (American Shad, River Herring, Atlantic Salmon, American Eel, Sturgeon, Sea Lamprey, Fish Passage, Habitat, and Fish Culture). Other experts and cooperators from the member agencies including the U.S. Geological Survey, Conte Anadromous Fish Research Center (CAFRC), Trout Unlimited, The Nature Conservancy, Connecticut River Watershed Council, and private industry, and others participate with the subcommittees and Technical Committee as needed. The Connecticut River Coordinator (Coordinator), now identified also as the Connecticut River Fish and Wildlife Conservation Office Project Leader, is an employee of the USFWS, acts as the Executive Assistant to the Commission and the Secretary for the Technical Committee and is the USFWS Technical Committee representative.

The Coordinator, as titled, is responsible for coordination of state and federal activities, providing technical expertise, project development and implementation of fish population assessments, restoration and management programs at the population and habitat level, program evaluation, regulatory input through Federal Power Act with FERC, and advocacy and outreach of the multi-agency cooperative diadromous fish restoration program in the Connecticut River watershed (Figure 1). The Coordinator also organizes meetings, identifies priorities, develops initiatives and plans, implements them, and maintains and develops partnerships to accomplish objectives.

Fish species under restoration and enhancement in the Connecticut River basin include American Shad, Blueback Herring, Sea Lamprey, American Eel, and Alewife, primarily addressed by efforts to provide upstream and downstream passage to historic habitats. Shortnose Sturgeon, the only federally endangered species and population, is under recovery and continues to be monitored, studied, and protected in a variety of ways, some of which will be covered in later text. Atlantic Sturgeon was considered extirpated from this river basin, with only transient individuals present from other populations, but new data from the State of Connecticut supports proof of successful reproduction that show genetic differentiation from the nearest “known” extant populations. This species was listed as Endangered under the Federal Endangered Species Act by NOAA Fisheries (NMFS) in 2012.

In 2016, adult Atlantic Salmon entering fishways with trap facilities were examined and given a visible streamer tag and passed upstream. Holyoke Fish Lift adult returns were taken to USGS CAFRC for swimming performance studies before being released after < 2 day retention period.

Assessments of returning adults will continue, providing data for CRASC and the U. S. Atlantic Salmon Assessment Committee work. Atlantic Salmon are expected to be a management topic requiring coordination through CRASC for a few more years, based on the last (final) large scale stocking that occurred in 2013, concluding the restoration effort. The CRASC continues to serve as an important mechanism to maintain communication and coordination on migratory fish restoration and management activities in the Connecticut River basin. Given the current status of main stem hydro facilities in FERC relicensing process and recent Holyoke Dam downstream passage (Settlement Agreement) measures, the need and value of a basin-wide management approach is important.

The CRASC meets at least twice each year and the Technical Committee meets as frequently as needed. This report period, the Commission met on November 13, 2015 and on June 28, 2016. The Technical Committee met on November 3, 2015 and June 27, 2016. Dr. Andrew Fisk (Massachusetts Public Member) was installed as the new Vice-Chair, to serve with Chair Mr. William Hyatt. CRASC scheduled meetings are open to the public, contact Ken Sprankle at ken_sprankle@fws.gov or at 413-548-9138 ext. 8121, to receive notices for scheduled meetings. Interested citizens are given the opportunity to provide input and area news publishers are notified of scheduled Commission meetings via email. Minutes of both Commission and Technical Committee meetings, once approved are available and posted on the Connecticut River FWCO website, https://www.fws.gov/r5crc/.

Table 1. Connecticut River Atlantic Salmon Commission Membership (as of November 2015).

Connecticut River Atlantic Salmon Commission	
Federal	**U.S. Fish and Wildlife Service** *Wendi Weber* Regional Director, Region 5 *Sherry White, alternate*
	National Marine Fisheries Service *John Bullard* Northeast Administrator *Daniel Morris, alternate*
Connecticut	**Connecticut Dept. of Energy and Environmental Protection** *William Hyatt (Chair)* Chief, Bureau of Natural Resources *Stephen Gephard, alternate*
	Public Sector Representative *Robert A. Jones*
Massachusetts	**Massachusetts Division of Fisheries and Wildlife** *Jack Buckley* Director *Mark Tisa, alternate*
	Public Sector Representative *Andrew Fisk (Vice Chair)*
New Hampshire	**New Hampshire Fish and Game Department** *Glenn Normandeau* Executive Director *Scott Decker, alternate*
	Public Sector Representative *Duncan McInnes*
Vermont	**Vermont Department of Fish and Wildlife** *Louis Porter* Commissioner *Eric Palmer, alternate*
	Public Sector Representative *Peter H. Basta*

Table 2. Connecticut River Atlantic Salmon Commission Technical Committee Membership.

Connecticut River Atlantic Salmon Commission Technical Committee	
Federal	**U.S. Fish and Wildlife Service** *Kenneth Sprankle*
	National Marine Fisheries Service *William McDavitt*
	U.S. Forest Service *Dan McKinley*
Connecticut	**Connecticut Dept. of Energy and Environmental Protection** *Stephen R. Gephard*
Massachusetts	**Massachusetts Division of Fisheries and Wildlife** *Caleb Slater* (Chair)
	Massachusetts Division of Marine Fisheries *Ben Gahagan*
New Hampshire	**New Hampshire Fish and Game Department** *Matthew Carpenter*
Vermont	**Vermont Department of Fish and Wildlife** *Lael Will*

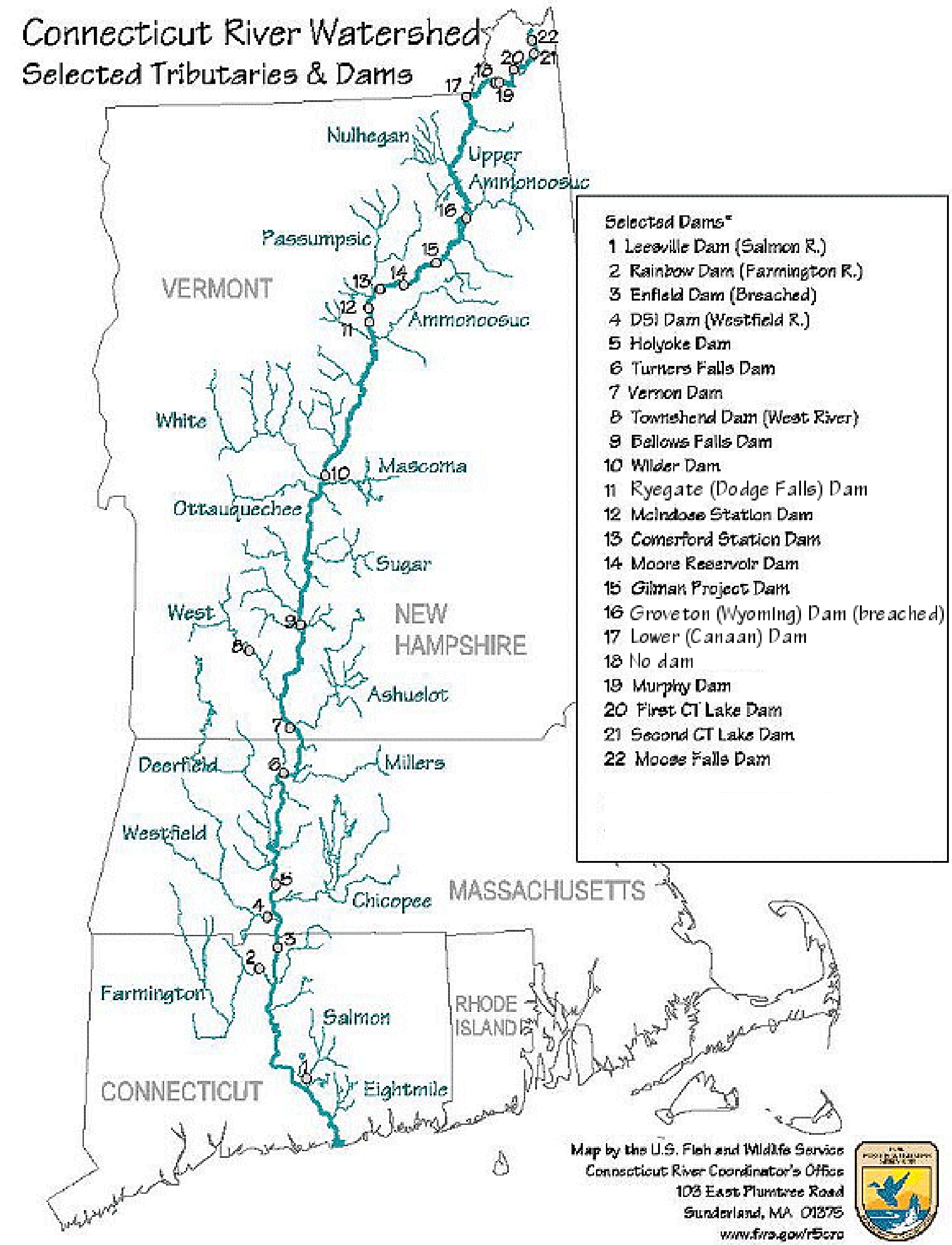


Figure 1. Connecticut River basin with major tributaries and main stem dams.

Coordination and Technical Assistance Funding

The Connecticut River Fish and Wildlife Conservation Office, under the USFWS' Wildlife and Sport Fish Restoration Program's F-100-R-33, for this report period, received $20,000 from the four state fishery agencies through the their annual Sport Fish Restoration Program apportionment (F-100-R). The grant project was assessed an USFWS administrative overhead fee (18%) leaving $16,393 available. The Office utilized the Sport Fish Restoration funds and USFWS Fisheries Program base funding for an operational budget totaling $305,579.44 for fiscal year 2016. The Sport Fish Restoration funds were fully drawn down to pay solely for the CTRFWCO building, office/equipment/operations, storage facility and vehicle maintenance expenses, allowing USFWS base funds to be applied in other operational areas.

Station total: $305,579.44 **States (F-100-R):** $16,393.44 **FWS Federal:** $289,186.00

Project Accomplishments

The Connecticut River Fish and Wildlife Conservation Office enhanced the Commission's and States' ability to manage, evaluate, and implement restoration programs through a variety of activities and accomplishments, some of which are described in greater detail in the following sections. Please note that data presented in this report has been reviewed to the extent possible, but is subject to change and should be considered provisional. **Use of any presented data should be discussed with the Coordinator to avoid potential issues with use, analyses, and/or interpretation**.

Coordination activities, select details:

- The Coordinator provided administrative support to the CRASC Commission and Technical Committee as the Executive Assistant and Secretary respectively, making meeting arrangements, establishing agendas, developing reports, distributing information, drafting correspondences, tracking finances, and recording and distributing minutes of Commission and Technical Committee meetings (four in the report period). The Coordinator participated on the CRASC Fish Passage, Shad and River Herring, Sea Lamprey subcommittees during this report period. The Coordinator served as the Chair for Shad and River Herring subcommittees and issued the Annual Fish Passage Notification letters on behalf of CRASC to main stem hydropower operators.

- The Coordinator served as the lead on the Plan Development Team that is updating the CRASC Management Plan for American Shad in the Connecticut River Basin. Substantial progress was made over time on this plan update. A final plan is expected in 2017.

- The Coordinator worked with Connecticut Department of Energy and Environmental Protection (CTDEEP), New Hampshire Fish and Game (NHFG), Rhode Island Division of Fish and Wildlife (RIDFW), U.S. Geological Survey, Conte Lab (USGS), and Holyoke Gas and Electric fishway staff to develop a shad trap and transfer schedule for the Holyoke Fish Lift. A summary of transfers are provided later in this report.

Fisheries Management, Restoration, Assessment, and Technical Assistance, additional select information:

- For the fourth consecutive year, a large scale population assessment program for river herring was initiated in late March, utilizing boat electrofishing as the primary sampling gear. Study objectives include: 1) obtain a minimum whole fish sample of 50 blueback and alewife for age structures, per target sample location/event; 2) obtain baseline demographic data on all sampled river herring (species, length, weight, sex); 3) derive relative abundance/catch measures; 4) conduct surveys across a broad geographic range of spawning aggregations and over the duration of the runs (April-June), representing spatial and temporal variations for both species; 5) determine fish ages from otoliths and spawning history from scale examinations; and 6) utilize standard stock assessment procedures and statistics to describe status and trends. This work was conducted to address identified priority data needs, specific to the Connecticut River and coast-wide, as described in the Atlantic States Marine Fisheries Commission's River Herring Benchmark Stock Assessment Report released in May 2012 (http://www.asmfc.org/uploads/file/riverHerringBenchmarkStockAssessmentVolumeIR_May2012.pdf). This assessment work is a long-term commitment by the CTRFWCO and will continue in future years. The assessment is intended to provide the varied data requirements and subsequent analyses required for responsible science-based restoration and management of these species.

  The ASMFC Shad and River Herring Technical Committee met in November 2015 to share river herring data collection designs, methods, and analytical approaches that were detailed in a published meeting report, available at: http://www.asmfc.org/uploads/file/56fc3c6dRH_DataCollectionStandardizaitionWorkshopSummary_March2016.pdf . The CTRFWCO program targets five sample areas; lower Mattabesset River (Middletown, CT), Wethersfield Cove (Wethersfield, CT), lower Farmington River (Windsor, CT), lower Westfield River (Agawam, MA), and lower Chicopee River (Chicopee, MA) for this monitoring program.

  Otoliths and scale samples were removed from fish returned to the laboratory from each sampling event, on the following day. Samples were uniquely labeled, cleaned and stored. Some information on effort and obtained samples sizes for the past four assessment years are shown in Table 3 and further described in the following narrative.

Table 3. Select sampling effort and field sample statistics for the river herring population assessment program 2013 - 2016.

	2013	**2014**	**2015**	**2016**
Number of sampling dates	18	21	20	25
Total sample runs	81	124	114	145
Total electrofishing seconds	41,177	55,736	56,025	71,845
Total bluebacks captured	714	2,593	1,448	1,586
Total alewives captured	107	220	258	586
Blueback herring otolith/scale - lab	501	655	622	730
Alewife otolith/scale - lab	103	188	165	461

In 2016, sampling was initiated earlier (March 30) than in past years and Alewife were sampled on that first outing. An increase in total effort occurred in 2016 compared to previous years with a total of 145 timed sampling runs completed over 25 sample dates. Sampling concluded on June 2, 2016.

Catch rates (fish/minute) for Alewife and Blueback Herring in 2016, for all sites combined, are presented in Table 4 with prior year rates also reported for comparison. The 2016 sample season provided generally sufficient sample sizes for study objectives, with the increased effort that occurred at most sites. However, catch rates were lower than in previous years for Blueback Herring, most notably in upstream sample sites in Massachusetts tributaries. Although the "aggregate" 2016 mean catch rates for Alewife was higher than in past years, it is still considered a very low value. The designation "positive" run in Table 4 was used to subset the field data, using only catch rates when the target species were sampled in a run. The "all runs" catch rates include all runs data for that year, with no censoring of data. The Alewife run begins and ends earlier than the Blueback Herring run, resulting in the need to consider timing of samples within and among years that is not addressed in this broadly based summary table. Variability for the summarized rates (reported standard deviation) is extremely high and other approaches to appropriately use these catch/effort data will be explored. A comprehensive interim report that will examine differences within site, among sites, and among years by site is planned for 2017.

Table 4. Summary statistics for Alewife (ALW) and Blueback Herring (BBH), by year, for electrofish sample runs that successfully captured the target species (positive) and alternatively for "all run data" (including "0" or no target fish capture). Relative abundance, in terms of fish/minute, by species and year are shown, for "positive capture runs" and for "all runs" by year.

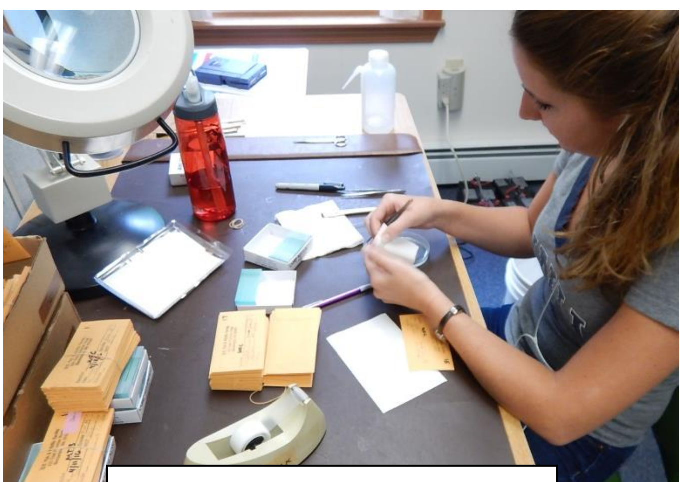
	2013		***2014***		***2015***		***2016***	
	ALW	**BBH**	**ALW**	**BBH**	**ALW**	**BBH**	**ALW**	**BBH**
Total Runs with (Positive) Target species	23 (28%)	44 (54%)	37 (30%)	69 (56%)	33 (29%)	65 (57%)	58 (40%)	71 (49%)
Total runs "0" target species	58 (72%)	37 (46%)	87 (70%)	55 (44%)	82 (71%)	49 (43%)	87 (60%)	74 (51%)
Positive Runs, **mean fish/min (± SD)**	0.57 (±0.44)	2.82 (±6.14)	0.76 (±0.77)	9.91 (±13.44)	0.94 (±1.08)	3.42 (±3.84)	1.24 (±1.62)	2.74 (±2.60)
All Runs (includes 0s), **mean fish/min (± SD)**	0.16 (±0.34)	1.52 (±4.7)	0.23 (±0.54)	5.52 (±11.15)	0.27 (±0.72)	1.95 (±3.35)	0.50 (±1.20)	1.34 (±2.27)

A summary of mean total lengths (mm) with standard deviations are shown in Table 5, by sex, for each species, by year. A one-way ANOVA detected significant differences ($P < 0.001$) among annual mean total lengths for both male and female Blueback Herring and Alewife. Post-hoc pairwise comparisons (Holm-Sidak) detected significant differences at $P < 0.05$ as indicated in Table 5, between years (within same species/sex).

Table 5. A summary of annual mean total length (mm) with standard deviations (SD), for all processed Blueback and Alewife, by sex, for the survey years of 2013 – 2016. ANOVA tests were followed by pairwise comparisons by species and sex. Significantly different pairwise comparisons (P < 0.05) are indicated by year letter assignment.

	Blueback				Alewife			
	Male		Female		Male		Female	
Year	Mean TL mm (± SD)	Signf. Diff.	Mean TL mm (± SD)	Signf. Diff.	Mean TL mm (± SD)	Signf. Diff.	Mean TL mm (± SD)	Signf. Diff.
2013^A	253.8 (12.1)	C, D	264.9 (12.6)	C, D	261.6 (15.8)	C, D	287.7 (16.2)	B
2014^B	253.8 (11.4)	C, D	264.9 (13.2)	C, D	266.2 (10.8)	C, D	276.1 (15.5)	A, C, D
2015^C	263.0 (10.4)	A, B, D	277.8 (11.7)	A, B, D	273.1 (11.7)	A, B	287.9 (12.4)	B
2016^D	265.2 (13.3)	A, B, C	281.3 (13.0)	A, B, C	270.7 (18.0)	A, B	286.4 (19.0)	B

All 2015 otolith samples for both Blueback and Alewife were read for age determination by late winter 2016, a total of 787 paired samples. Previous year scale samples for both Alewife and Blueback Herring were cleaned from stored sample envelopes, mounted on slides and read for spawning marks/ spawning history determinations. This significant effort was completed by the interns and staff during the summer and fall. Scale reading was also completed for past year samples for both species (~10% remaining) and completed for 2016, for both species. Otolith reading was also completed earlier than in past years for the 2016 samples, with all 1,191 otolith sets read for age assignments in this report period. Work to re-examine the accuracy of the first and second year age assignments has been initiated along with a training set for readers. Consultation with Massachusetts Division of Marine Fisheries for otoliths and the State of Connecticut for scale readings has been ongoing.


Cleaning and mounting fish scales


Lab processing of fish

Length frequency plots describing size distributions by sex, over time, have been developed in aggregate and at the site specific level. An example of observed shifts in size structure is shown in Figure 2, for Blueback Herring sampled from the Farmington River. A positive shift in the size distribution is apparent over time, but additional information is required for considering the extent of influence by year class strength. Having preliminary age data for all lab processed Blueback Herring from the reading of otoliths, the contributions of age classes (from the random subsample) is shown by year in Figure 3. The proportional age assignment for each year (2013-2016) is shown for combined sexes and by sex, ranging from as young as age-3 to the very limited occurrence of age-9 fish. The presence of the 2010 cohort, that appear disproportionate (over 60% within year contribution) to other ages beginning in 2014 as age-4 fish, is shown for both males and females and continues its presence in 2015 and 2016 with an expected decline.

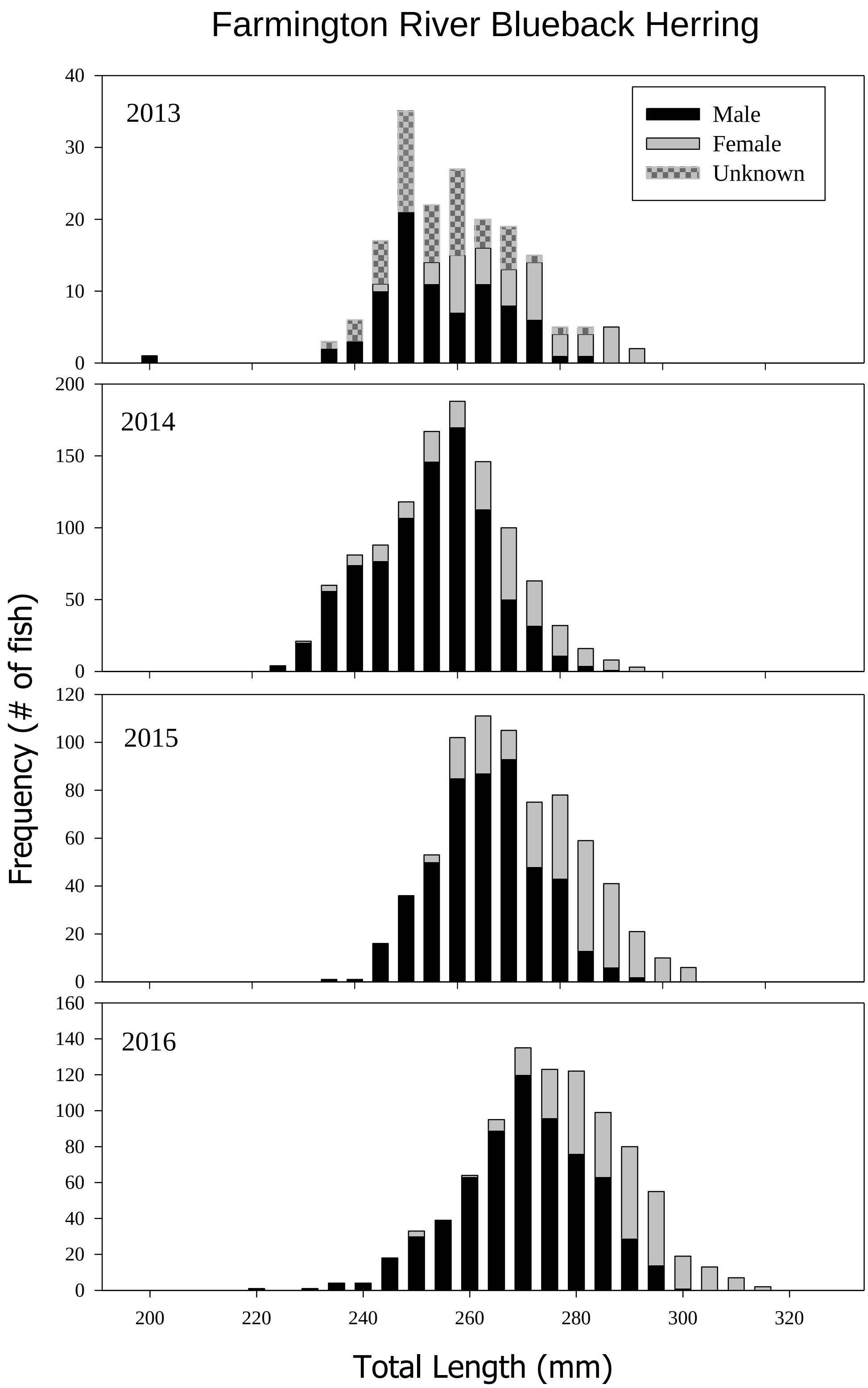


Figure 2. Length frequency distributions (total length, mm), by sex, for all Blueback Herring sampled in each identified study season (2013 – 2016).

The CTDEEP juvenile index for BBH in 2010 was a substantially greater value than observed in the preceding 14 years and in subsequent years (Appendix B). The Farmington River data indicate, in a relative context, low abundances of age-3 and age-4 fish in 2015 and 2016, which is of concern. The CTDEEP reported at the Fall 2016 CRASC meeting that provisional survey results indicate a very high JI value for American Shad and the lowest observed value for Blueback Herring since the inception of the survey.

Preliminary results from the reading of Blueback Herring scales for spawning marks, for samples obtained from the Farmington River in 2016, indicate the greatest percentage of females (50%) were spawning for a second time, at the time of their capture in 2016 (Table 6). This compares to an equal proportion of first time (virgin) and second time spawners for males that comprised 84% of that subsample. Sample sizes are very low for older age fish for both sexes (age-9; one male and two females) and require caution in interpretation.

Table 6. Spawning history assignments (%), by sex and age, for Blueback Herring sampled from the Farmington River in 2016.

	Female (%)					**Male (%)**			
	First	**2nd**	**3rd**	**4th**	**5th**	**First**	**2nd**	**3rd**	**4th**
Age-3	100.0					94.1	5.9		
Age-4	100.0					85.7	14.3		
Age-5	52.7	41.6	5.5			48.4	43.5	8.1	
Age-6	17.9	64.1	12.8	5.1		31.3	51.0	15.6	2.1
Age-7	20.0	80.0				14.3	28.6	42.9	14.3
Age-8	25.0	25.0	25.0		25.0		66.7		33.3
Age-9		50.0	50.0					100.0	
Total N	**34**	**46**	**9**	**2**	**1**	**84**	**84**	**27**	**5**
Total %	**36.9**	**50.0**	**9.8**	**2.2**	**1.1**	**42.0**	**42.0**	**13.5**	**2.5**

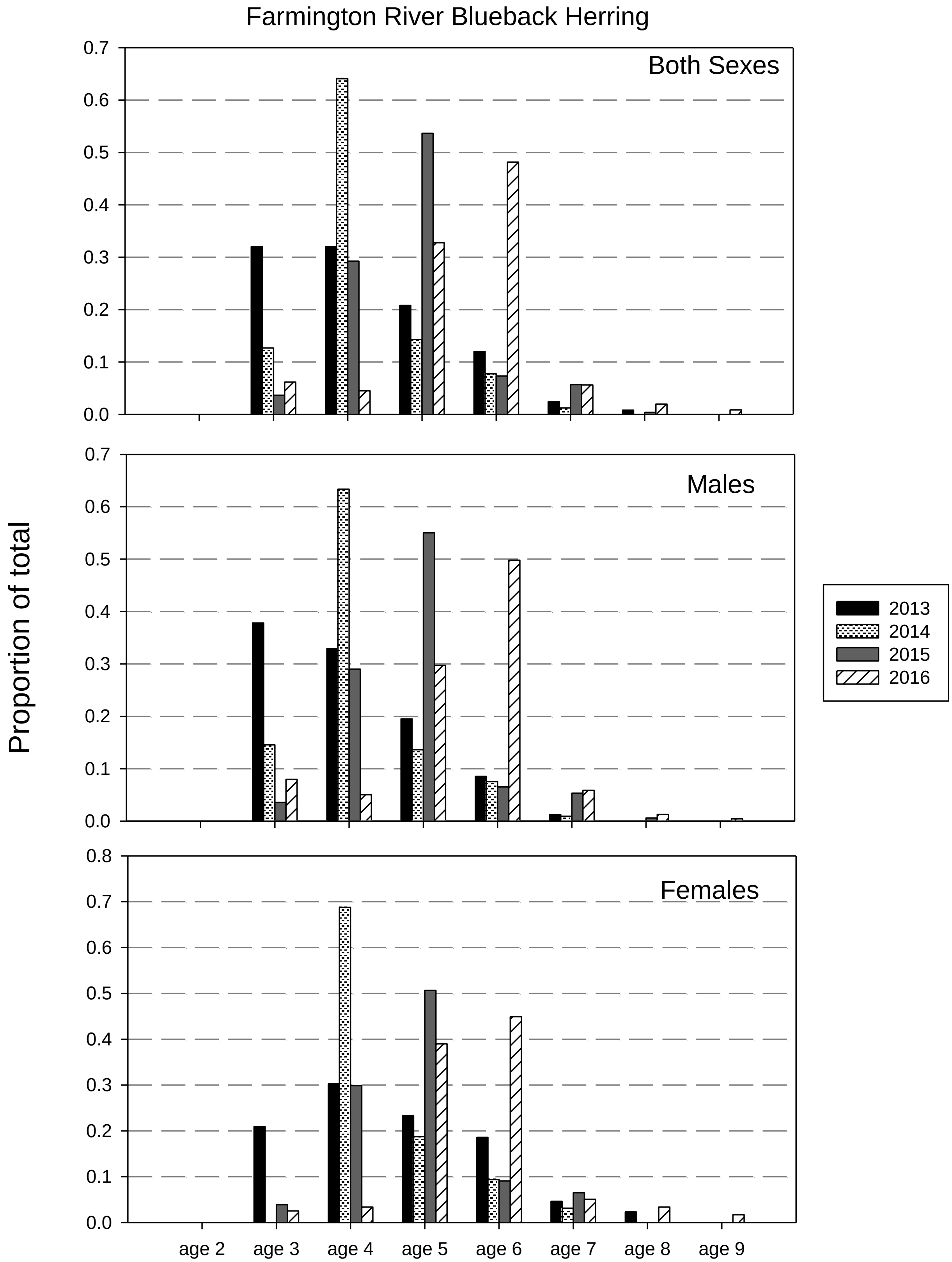


Figure 3. Proportional age assignments for all Blueback Herring aged from otolith samples in each year (2013-2016), both sexes combined and sex specific, from the Farmington River.

- Active river herring restoration measures were initiated in 2016 as Blueback Herring catch rates in population assessment work increased. In the month of May, on three dates, the Office conducted capture/transfers of pre-spawn herring from Wethersfield Cove, concurrent with population assessments. Similar to the past years, boat electrofishing was used on three dates to capture a total of 1,004 herring that were transferred to accessible but unutilized habitats upstream of Holyoke Dam (Table 6). This was the second consecutive year of a decrease in the number that were captured and transferred. Fish were transported in two USFWS tank trucks with salt, diffused oxygen, and recirculating water pumps. Sampling for juvenile production was conducted in the early fall and produced catch rates similar to past year evaluations at the expected larger size than juveniles sampled from Wethersfield Cove, CT.

Sampling of juveniles river herring

- A summary of American Shad transfers from Holyoke Fish Lift to support restoration efforts in and out-of-basin, with stocking locations, and for research are provided in Table 7. This Office was able to load and re-locate a total of 976 American Shad upstream of the Rainbow Dam over a period of nine dates in June, in support of CTDEEP efforts to increase juvenile production upstream of that dam. In addition USGS Conte Lab used American Shad for research on fishway entrance weir configurations, with the subsequent release of these study fish immediately upstream of Turners Falls Dam. The Conte Lab also continued research on spawning and reproduction performance under varied temperatures (those study fish not identified as released).

New fish tank on transport truck, releasing American Shad

Table 7. Fish transfers for Blueback Herring and American Shad in spring of 2016. All Blueback Herring captured in Wethersfield Cove, Wethersfield, Connecticut. All American Shad were taken from the Holyoke Fish Lift.

Species	Destination	Destination Waterbody	Destination State	Number Transported	Transported By	Date	Number Released	Transport Mortalities	Release Sum by grouping
Bluebacks	EASTHAMPTON/OXBOW	CT RIVER	MA	225	USFWS	10-May-16	225	0	
Bluebacks	EASTHAMPTON/OXBOW	CT RIVER	MA	315	USFWS	11-May-16	315	0	
Bluebacks	EASTHAMPTON/OXBOW	CT RIVER	MA	470	USFWS	25-May-16	464	6	1,004
Shad	WINCHESTER	ASHUELOT RIVER	NH	42	RIDFW	10-May-16	42	0	
Shad	WINCHESTER	ASHUELOT RIVER	NH	76	RIDFW	17-May-16	76	0	
Shad	WINCHESTER	ASHUELOT RIVER	NH	75	RIDFW	24-May-16	75	0	
Shad	WINCHESTER	ASHUELOT RIVER	NH	82	RIDFW	25-May-16	82	0	
Shad	WINCHESTER	ASHUELOT RIVER	NH	76	RIDFW	26-May-16	76	0	351
Shad	CONTE LAB	CONTE LAB	MA	12	CONTE LAB	27-Apr-16	12	0	
Shad	CONTE LAB	CONTE LAB	MA	100	CONTE LAB	13-May-16	100	0	
Shad	CONTE LAB	CONTE LAB	MA	80	CONTE LAB	02-Jun-16	80	0	
Shad	CONTE LAB	CONTE LAB	MA	42	CONTE LAB	24-Jun-16	42	0	
Shad	Post Flume trials GILL	CT RIVER	MA	97	CONTE LAB	02-May-16	97	0	
Shad	Post Flume trials GILL	CT RIVER	MA	47	CONTE LAB	03-May-16	47	0	
Shad	Post Flume trials GILL	CT RIVER	MA	66	CONTE LAB	09-May-16	66	0	
Shad	Post Flume trials GILL	CT RIVER	MA	113	CONTE LAB	10-May-16	113	0	
Shad	Post Flume trials GILL	CT RIVER	MA	132	CONTE LAB	11-May-16	131	1	
Shad	Post Flume trials GILL	CT RIVER	MA	122	CONTE LAB	12-May-16	120	2	
Shad	Post Flume trials GILL	CT RIVER	MA	82	CONTE LAB	15-May-16	80	2	
Shad	Post Flume trials GILL	CT RIVER	MA	30	CONTE LAB	16-May-16	30	0	
Shad	Post Flume trials GILL	CT RIVER	MA	113	CONTE LAB	17-May-16	113	0	
Shad	Post Flume trials GILL	CT RIVER	MA	111	CONTE LAB	18-May-16	111	0	
Shad	Post Flume trials GILL	CT RIVER	MA	64	CONTE LAB	19-May-16	62	2	
Shad	Post Flume trials GILL	CT RIVER	MA	122	CONTE LAB	23-May-16	122	0	
Shad	Post Flume trials GILL	CT RIVER	MA	109	CONTE LAB	24-May-16	109	1	
Shad	Post Flume trials GILL	CT RIVER	MA	115	CONTE LAB	25-May-16	115	0	
Shad	Post Flume trials GILL	CT RIVER	MA	63	CONTE LAB	26-May-16	63	0	
Shad	Post Flume trials GILL	CT RIVER	MA	63	CONTE LAB	30-May-16	63	0	
Shad	Post Flume trials GILL	CT RIVER	MA	117	CONTE LAB	31-May-16	113	4	
Shad	Post Flume trials GILL	CT RIVER	MA	119	CONTE LAB	01-Jun-16	116	3	
Shad	Post Flume trials GILL	CT RIVER	MA	32	CONTE LAB	02-Jun-16	30	2	
Shad	Post Flume trials GILL	CT RIVER	MA	32	CONTE LAB	03-Jun-16	19	13	
Shad	Post Flume trials GILL	CT RIVER	MA	34	CONTE LAB	04-Jun-16	26	8	
Shad	Post Flume trials GILL	CT RIVER	MA	106	CONTE LAB	06-Jun-16	103	3	
Shad	Post Flume trials GILL	CT RIVER	MA	114	CONTE LAB	07-Jun-16	114	2	
Shad	Post Flume trials GILL	CT RIVER	MA	67	CONTE LAB	08-Jun-16	66	1	
Shad	Post Flume trials GILL	CT RIVER	MA	65	CONTE LAB	09-Jun-16	62	3	
Shad	Post Flume trials GILL	CT RIVER	MA	64	CONTE LAB	13-Jun-16	64	0	
Shad	Post Flume trials GILL	CT RIVER	MA	68	CONTE LAB	15-Jun-16	68	0	
Shad	Post Flume trials GILL	CT RIVER	MA	65	CONTE LAB	16-Jun-16	61	4	2,518
Shad	WINDSOR	FARMINGTON RIVER	CT	87	CTDEEP	27-May-16	87	0	
Shad	WINDSOR	FARMINGTON RIVER	CT	82	CTDEEP	01-Jun-16	81	1	
Shad	WINDSOR	FARMINGTON RIVER	CT	152	USFWS	01-Jun-16	149	3	
Shad	WINDSOR	FARMINGTON RIVER	CT	120	USFWS	02-Jun-16	120	0	
Shad	WINDSOR	FARMINGTON RIVER	CT	120	USFWS	03-Jun-16	120	0	
Shad	WINDSOR	FARMINGTON RIVER	CT	126	USFWS	07-Jun-16	126	0	
Shad	WINDSOR	FARMINGTON RIVER	CT	131	USFWS	08-Jun-16	130	1	
Shad	WINDSOR	FARMINGTON RIVER	CT	75	USFWS	09-Jun-16	74	1	
Shad	WINDSOR	FARMINGTON RIVER	CT	121	USFWS	10-Jun-16	119	2	
Shad	WINDSOR	FARMINGTON RIVER	CT	70	USFWS	14-Jun-16	70	0	
Shad	WINDSOR	FARMINGTON RIVER	CT	68	USFWS	17-Jun-16	68	0	1,144
Shad	BERLIN	MATTABESSET RIVER	CT	93	CTDEEP	15-Jun-16	93	0	93
Shad	NORTH ATTLEBORO	NANFH	MA	75	RIDFW	11-May-16	75	0	
Shad	NORTH ATTLEBORO	NANFH	MA	75	RIDFW	12-May-16	75	0	
Shad	NORTH ATTLEBORO	NANFH	MA	76	RIDFW	18-May-16	76	0	
Shad	NORTH ATTLEBORO	NANFH	MA	80	RIDFW	19-May-16	80	0	
Shad	NORTH ATTLEBORO	NANFH	MA	80	RIDFW	31-May-16	79	1	385
Shad	BEACON FALLS	NAUGATUCK RIVER	CT	77	CTDEEP	02-Jun-16	72	5	72

American Shad from Holyoke Fish Lifts were taken to the North Attleboro National Fish Hatchery were natural spawning was used to produce larval shad to support restoration stocking efforts in Rhode Island targeted river habitats. As part of the agreement for use of these fish the Rhode Island DEM transferred 351 American Shad upstream of the third dam on the Ashuelot

River. In 2017 monitoring efforts need to be directed at Fiske Mill Dam (Hinsdale, NH) to determine whether there are American Shad present downstream of that first dam on the Ashuelot River, which has an operating fish lift, but has never reported passing any shad or Sea Lamprey. In 2016 both USFWS and NHFG reviewed the project and provided recommendations, given issues with the location of the entrance to the fishway, a follow-up is planned in 2017.

- Sea Lamprey nest counts were conducted in late June and early July in a number of tributaries, some of which have previous survey data (Table 8). Surveys were conducted in identified river segments, often downstream of the first barrier an up-running lamprey would encounter.

Table8. Time series of Sea Lamprey nest surveys in select tributaries, in defined reaches.

Year	Green R. (Greenfield, MA)	Manhan R. (below Easthampton Dam, MA)	Manhan R. (upstream of ladder)	Sawmill R. (Montague, MA)	Fall R. (Greenfield, MA)	Dry Brook (Gill, MA)	Ashuelot R. (Hinsdale, NH)	West R. (Townshend, VT)
2009	55							
2010	184	20						
2011	84	35		142	133			
2012								
2013								
2014	29	28	72		30			
2015	71	13	5	34	44[A]			
2016	87	4	18	112	15	7	320	42[B]

[A] - additional 14 nests in the area 90 lamprey were transferred, upstream of removed dam

[B] - additional 27 nests in short 100 meter section of habitat downstream several km

River	*Location details*
Green R.	*From Wiley Russell Dam (1st dam) to downstream end of habitat (0.9 km)*
Manhan R.	*Below dam at Easthampton, limited habitat, ~ 100 meters*
Manhan R. (Upstream of ladder)	*N. Branch from Torrey Rd, downstream to main stem confluence and main stem to Glendale Street (3.3 km)*
Sawmill R.	*Bookmill ledge to Meadow Rd Bridge crossing (1.6 km)*
Fall R.	*From natural ledge to mouth (0.5 km)*
Dry Brook	*From 1st Dam to mouth (0.4 km)*
Ashuelot R.	*From 1st Dam to end of habitat (1.7 km)*
West R.	*From ACOE Flood Control Dam downstream (1.2 km)*

- A significant portion of time was spent on the FERC relicensing process for the Turners Falls Dam and Northfield Mountain Pumped Storage (NMPS) Project operated by FirstLight Power and TransCanada's Vernon Dam, Bellows Falls Dam, and Wilder Dam. The FERC licensing process (all licenses expire in 2018) was initiated in fall of 2012 and activities occurred throughout the report period. The office web site (http://www.fws.gov/r5crc) provides links to both FirstLight Power and TransCanada's web sites where documents for this process are posted.

  In this report period, meetings to further define study plans by the power companies and consultants continued and meetings and conference calls occurred including those only among the resource agency/members group. Study reports, study report revisions and addendums, have been released over this time period by the companies, which have been reviewed, and comment/response letters developed and submitted to FERC by the Service. This work is ongoing.

- Long-term temperature loggers (n=16) from Rocky Hill, Connecticut, upriver to Wilder Dam, (Vermont/New Hampshire) were maintained in late summer and early fall 2016. Loggers record temperature year-round at 20 minute intervals. Data from these loggers were used in later figures as an additional plotted variable with fish passage figures for Holyoke Fish Lifts as well as for partner researcher use (NOAA/NMFS and USGS Conte) and others requestors (Holyoke Gas and Electric).

- The Coordinator spent one week in September assisting in the collection of water velocity profile data as part of a Dwarf Wedge Mussel research study in the upper main stem river. The research will examine habitat and population/occurrence in areas surveyed for this federally endangered species in the main stem river (upstream of Wilder Dam, Wilder, Vermont, to the Town of Stratford, New Hampshire). This project is being led by Melissa Grader (USFWS) and Katie Kennedy (The Nature Conservancy).

- Phil Herzig (USFWS Fish Biologist), working from this office, used his seasonal staff and CTRFWCO staff, to complete road/stream crossing assessments in the Nulhegan National Wildlife Refuge in Vermont. Phil also administered a USFWS grant that will support the removal of the Norton Dam (Colchester, CT) in the Salmon River basin (occurred after report period).

USFWS interns assessing a culvert

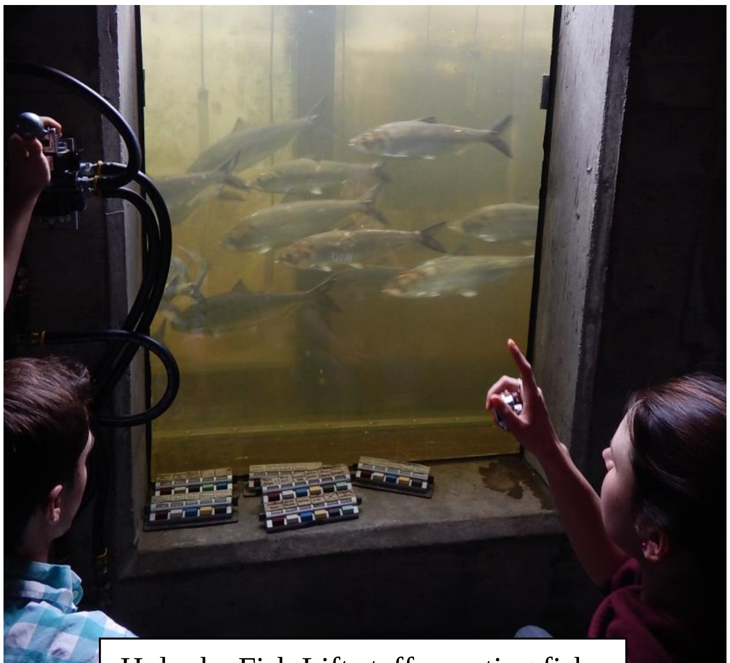
- Lori Benoit (USFWS Fish and Wildlife Biologist), from the Southern New England Coastal Program Office (Rhode Island), completed required permitting to support CTDEEP with the removal of the Springborn Dam on the Scantic River (Enfield, CT).

- The Coordinator updated the station website on the Internet (http://www.fws.gov/r5crc) with current information and activities. Replied to ongoing data requests on fishway counts, river herring assessments, and temperature loggers.

- The Office continued to maintain databases on migratory fish restoration activities. Daily fish counts at different dams were entered into databases. Fish counts were updated in-season at frequent interval (every few days) during the spring, with email notifications to individuals and postings to the office's web site (Appendix A).

Program Results

The Connecticut River Fish and Wildlife Conservation Office collected and reported information relating to the activities and accomplishments occurring in the Connecticut River basin diadromous fisheries restoration program. Note some of the data presented here are preliminary, not all counts were final at the time of this report (Appendix A).



Holyoke Fish Lift staff counting fish

Migratory Fish Returns

American Shad - A total of 392,057 adult American Shad were counted in 2016 at all first barrier passage facilities in the basin. A total of 385,930 American Shad were passed upstream of the Holyoke Dam, Massachusetts, in 2016 through its two fish lifts (Figure 4). The mean passage count at Holyoke for the period 1976-2015 is 309,041 (±SD 131,363). The 25th and 75th percentile values for passage counts are 193,224 and 374,917 respectively. The American Shad passage count at Holyoke Fish Lift, as a population metric with a number of caveats, has for the fourth year in a row exceeded the 75th percentile (Figure 4). Water temperatures declined in early April and American Shad passage activity at Holyoke Dam ceased after a few initial fish were passed on April 1, and then passage counts picked back up in the middle of the month at a slow, increasing rate. A record single passage day for American Shad occurred on 5/12/2016 at Holyoke Fish Lift, with 54,004 shad counted, surpassing the previous daily record of 53,011 in 1983 (Figure 5). There are sixteen daily counts that have ranged from 40,000 to 50,000 over the Holyoke Fish Lifts' data time series for American Shad.

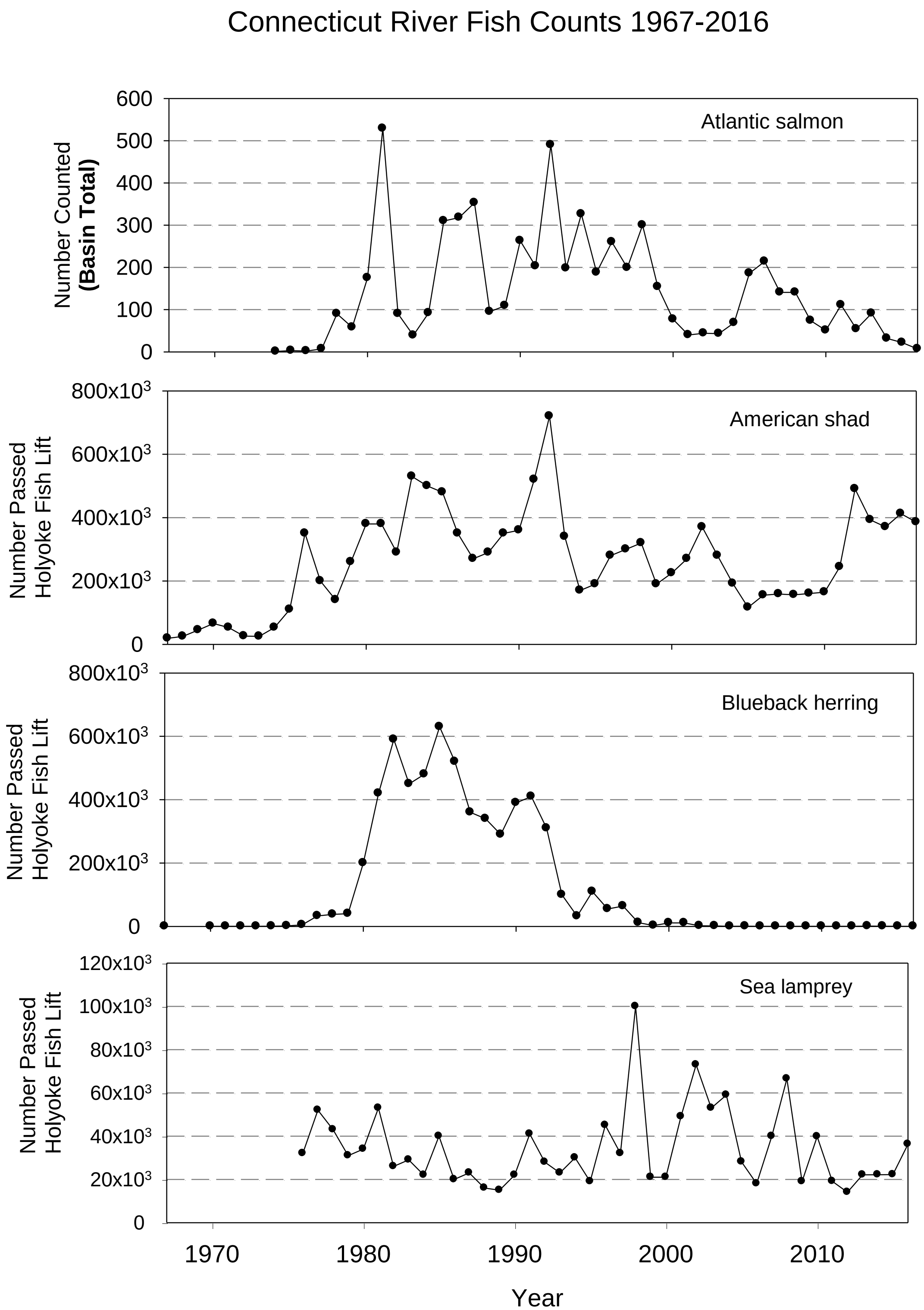


Figure 4. Select count summary of Atlantic Salmon returns to Connecticut River basin (all facilities), and Holyoke Fish Lift passage counts for American Shad, Blueback Herring and Sea Lamprey (1967-2016). Fish counts are affected by structural and operational changes at both dams and fishways, and by environmental conditions (temperature and flow/spill) within year and among years.

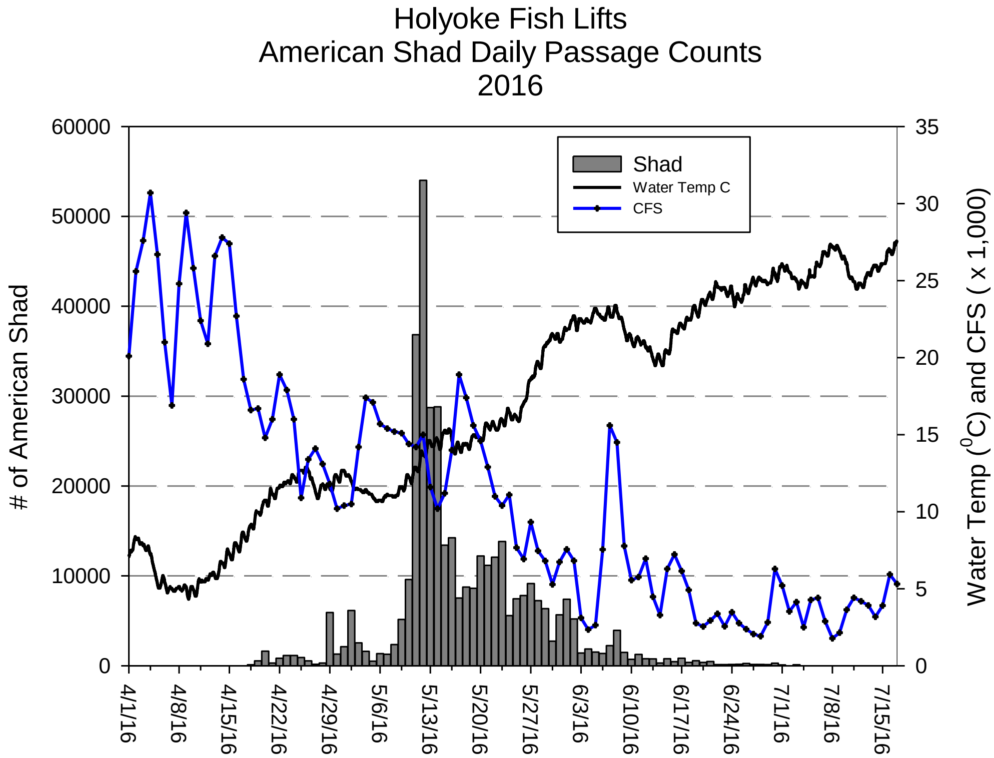


Figure 5. Daily American Shad counts from Holyoke Fish Lifts with water temperature (USFWS) and river discharge (USGS) data included for the period April 1 to July 15, 2016.

A total of 5,940 American Shad were passed upstream of the West Springfield Project in 2016 on the Westfield River, which is an increase from 2014 (3,383 passed) and greater than the long-term mean of 3,300. The record high American Shad passage count at that facility was 10,300 in 2012. A total of 141 American Shad were passed upstream of the Rainbow Dam Fishway on the Farmington River in Connecticut, a fishway with known upstream passage issues for this species.

Of the American Shad passed upstream of the Holyoke Dam, 54,069 shad were counted passing the Gatehouse Ladder at Turners Falls Dam in 2016 (Table 9). The Turners Falls Dam and power canal is a three fishway complex. Fish must first pass either the Cabot Station Ladder (into the power canal) or the Spillway Ladder, at the base of the dam and upstream end of the bypassed reach. Fish passing the Cabot Ladder exit into the lower power canal that requires finding one of two entrances to the Gatehouse Ladder at the upstream end of the canal. Spillway Ladder passed fish may go directly to the entrance of the Gatehouse Ladder, but as in the case of all ladders, have opportunities to drop back, including into the canal.

Overall, the 2016 passage number at Gatehouse Ladder as a percentage of American Shad passed at Holyoke is 14.0%, nearly identical to the 14.1% value observed in 2015, the two highest values in the time-series (Table 9). The CRASC Shad Management Plan has an objective of 40-60% upstream passage at each successive barrier on the main stem. As a result, the minimum 2016 upstream passage count objective for Turners Falls Gatehouse would have been 156,822 American shad. At the next upstream barrier, Vernon Dam (Vernon, Vermont), the single fish ladder passed a total of 35,513 American Shad, down only slightly from the record set in 2015 (37,771 passed). Vernon Dam Ladder passed 65.7% of the American Shad counted passing from the Turners Falls Gatehouse Ladder (Table 8).

Table 9. American Shad fishway passage counts for the period of 1980 – 2016, for Holyoke Dam, Turners Falls Dam (Gatehouse Ladder), and Vernon Dam.

Year	HFL Passed	Gatehouse Passed	% Gate vs. HFL #	Vernon Passed	%Vern vs. Gate #
1980	380,000	298	0.1		
1981	380,000	200	0.1	97	48.5
1982	290,000	11	0.0	9	81.8
1983	530,000	12,705	2.4	2,597	20.4
1984	500,000	4,333	0.9	335	7.7
1985	480,000	3,855	0.8	833	21.6
1986	350,000	17,858	5.1	982	5.5
1987	270,000	18,959	7.0	3,459	18.2
1988	290,000	15,787	5.4	1,370	8.7
1989	350,000	9,511	2.7	2,953	31.0
1990	360,000	27,908	7.8	10,894	39.0
1991	520,000	54,656	10.5	37,197	68.1
1992	720,000	60,089	8.3	31,155	51.8
1993	340,000	10,221	3.0	3,652	35.7
1994	170,000	3,729	2.2	2,681	71.9
1995	190,000	18,369	9.7	15,771	85.9
1996	280,000	16,192	5.8	18,844	116.4
1997	300,000	9,216	3.1	7,384	80.1
1998	320,000	10,527	3.3	7,289	69.2
1999	190,000	6,751	3.6	5,097	75.5
2000	225,000	2,590	1.2	1,548	59.8
2001	270,000	1,540	0.6	1,744	113.2
2002	370,000	2,870	0.8	356	12.4
2003	280,000	Not available		268	
2004	192,000	2,192	1.1	653	29.8
2005	116,511	1,581	1.4	167	10.6
2006	155,000	1,810	1.2	133	7.3
2007	158,807	2,248	1.4	65	2.9
2008	156,492	4,000	2.6	271	6.8
2009	160,649	3,813	2.4	16	0.4
2010	164,439	16,422	10.0	290	1.8
2011	244,177	16,798	6.9	46	0.3
2012	490,431	26,727	5.4	10,386*	38.9
2013	392,494	35,293	9.0	18,220	51.6
2014	370,506	39,914	10.8	27,706	69.4
2015	412,656	58,079	14.1	39,771	68.5
2016	385,930	54,069	14.0	35,513	65.7

*an example of a fishway issue that was identified (telemetry study), resolved (USFWS Engineers and TransC) that resulted in the observed increase in passage counts, effective in 2012.

A new American Shad passage record was set in 2016 at Bellows Falls Dam, with 1,973 fish counted passing that project's fish ladder. This count surpasses the previous high record of 147 American Shad at Bellows Falls Ladder observed passing in 1995. However, this project's ladder was, by agreement, operationally triggered on Atlantic Salmon upstream passage needs, so its period of operation was often limited/restricted in the past. Bellows Falls has been reported to be the historic upstream extent of the species range. In many years no shad were observed passing at this facility, but the restricted operational period is a confounding factor over time. Beginning in 2013, TransCanada agreed to open this ladder based on a trigger of 100 Sea Lamprey passed at Vernon Dam following a request from CRASC, providing an opportunity for upstream habitat access to these species and others (e.g., American Eel).

The performance of a fishway (both up and downstream) cannot only be measured in the numbers of fish they pass but must consider the time taken to pass (rates), addressing the important issue of delay. Delay may be caused by ineffective attraction to the entrance areas of fishways, issues at the entrances and with entry, and internal ladder/fishway efficiency or other project operational situations. The concern with delay is based on the fact that American Shad are migrating on stored energy reserves, so the additive amount of delay (for both upstream and downstream migrations) increases the likelihood of mortality. Through this mechanism, under a variety of upstream and downstream passage situations, the possibility for a future opportunity to return as a repeat spawner may be reduced or eliminated. The Connecticut River American Shad population is iteroparous (can spawn repeatedly, over years) that may serve to increase population resilience in the case of poor reproduction (buffer), increase reproductive capacity (larger older fish have exponential increases in fecundity) and increase overall annual run population abundance. In addition to the importance of timely passage, passage must also be safe, on upstream and for downstream migrating post spawn adults and juveniles. Here again, the fact that a portion of the fish passed upstream face "additive" effects from hydroelectric projects encountered in sequence, must be carefully considered and can be addressed. Study reports and results submitted to FERC for relicensing requirements on American Shad movement, passage, and survival at dams, facilities, and fishways (both up and downstream passage), are being revised, following review letters from the USFWS and partner agencies.

Shortnose Sturgeon - A total of 94 Shortnose Sturgeon were captured in the Holyoke Fish Lifts in 2016, a new record, surpassing the previous high value of 16 in 1996 (Figure 6). The new spillway entrance work completed in 2015 and operational for 2016, had included among other objectives, improving the ability to pass Shortnose Sturgeon. Those modifications have been credited with the observed increase in sturgeon entering that fishway entrance. However, over the course of the spring of 2016, NOAA Fisheries was unable to approve/come to agreement on an acceptable study plan to evaluate, through a radio tagging study design, if passing sturgeon upstream was not subsequently harmful to passed fish (e.g., fallback behavior). As a result, all Shortnose Sturgeon that entered the Fish Lift in 2016 were trapped, processed for biological data, the presence of a tag, tagged if untagged (small PIT tag only), and then released back downstream in the tailrace. The previously noted tags used at the lift this season are passive integrated transponder PIT not the "radio" or "acoustic" tags that will be part of the required evaluation(s) that can be detected at distance as opposed to the PIT tags limited ~1 meter read range. The Holyoke Fish Lift crew reported in 2016 that over 80% of the trapped sturgeon came from the spillway side entrance. As all sturgeon were tagged before release, it was determined that 15 fish returned and were trapped again, and out of that subgroup a number returned more than once. Taking the repeat entry fish into account, there were a total of 79 unique fish that were trapped. In mid-summer, it was decided that the Fish Lift should cease operations due to fish health concerns in higher water temperatures, eliminating the handling and processing of fish destined to be released back below the project. Upon re-opening the lift on September 1, only one Shortnose Sturgeon was subsequently trapped several days later for the remainder of the fall.

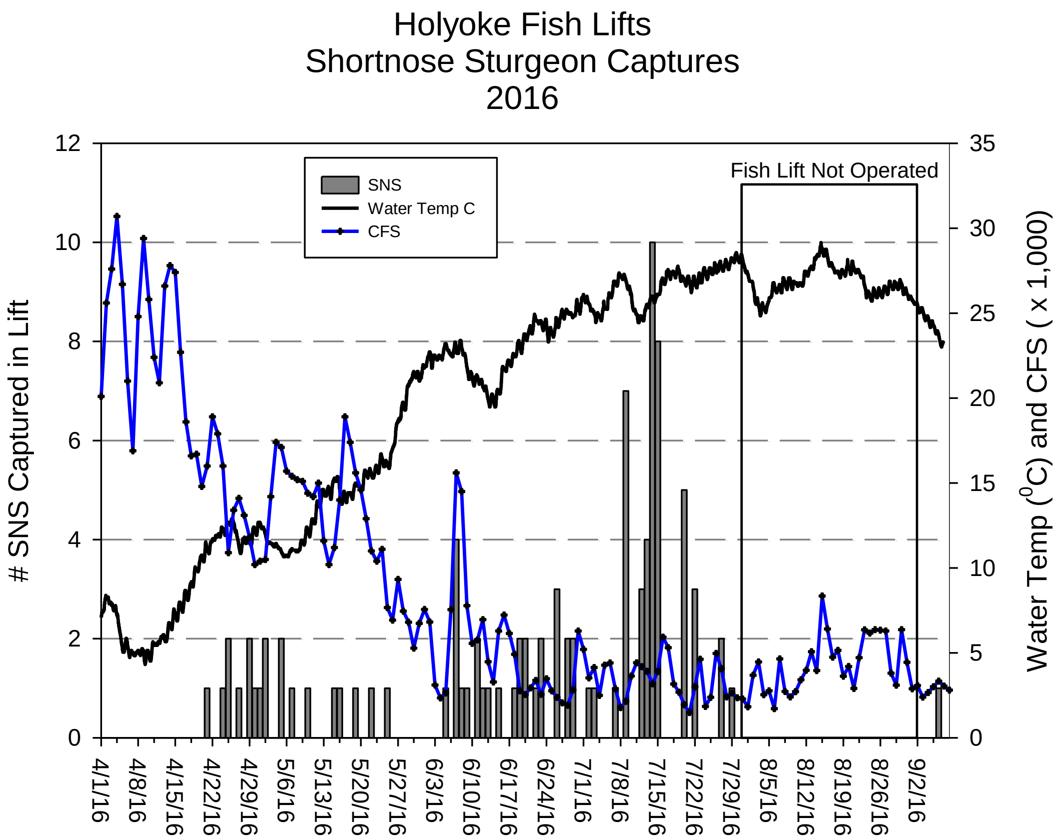


Figure 6. Daily Shortnose Sturgeon captures at the Holyoke Fish Lifts in 2016, in relation to water temperature and river discharge. Note that the Holyoke Fish Lift operations were suspended at the end of July as the observed water temperatures were a concern for stress with the handling and processing of fish.

Blueback Herring - A total of 137 Blueback Herring were counted at the Holyoke Fish Lift in 2016 (Figure 4). River herring counts are not believed to reliably serve as a population metric for the lower main stem river/basin, and larger lower basin tributaries (downstream of first barrier/fishways), where substantial spawning habitat occurs (refer to earlier report sections). The CRASC River Herring Management Plan identifies a passage goal of 500,000 at the Holyoke Fish Lift. That goal had been attained and exceeded prior to population declines observed along much of the East Coast in the past two decades.

Sea Lamprey - A total of 36,245 Sea Lamprey were observed from first barrier fishways or estimated by nest counts (CTDEEP nest counts) returning to the Connecticut River basin in 2016. This is a substantial increase (~44%) from the total 2015 counts, driven primarily by the Holyoke Fish Lift. Holyoke passed a total of 35,249 Sea Lamprey in 2016 compared to 22,245 passed in 2015 (Figure 4). The 2016 count at Holyoke is close to the long-term mean annual count of 34,000 at that facility. A total of 15,128 Sea Lamprey subsequently passed upstream of Turners Falls Dam (through Gatehouse Ladder), or 43% of the number passed at Holyoke. In 2015 a total of 8,423 Sea Lamprey passed the Gatehouse Ladder at Turners Falls. A total of 5,521 passed upstream of Vernon Dam (or 36% of Gatehouse Ladder total). A total of 1,619 passed upstream of Bellows Falls Dam compared to 971 (2015). In the lower river basin, only 494 Sea Lamprey passed at Rainbow Dam, Farmington River, a decrease from the 1,591 passed in 2015 and the 4,276 passed in 2014. A total of 449 Sea Lamprey passed upstream of the West Springfield fishway, compared to 216 in 2015 and 1,127 in 2014.

Striped Bass - A total of 638 Striped Bass were counted at the Holyoke Fish Lift in 2016 and were noted to be of a smaller size range than typically observed in previous spring passage seasons. The 2016 count is a substantial increase from the 21 passed in 2015 and the 69 passed in 2014. The USFWS River Herring Assessment also noted anecdotally an increase in the abundance of smaller striped bass observed, in the size range of 300 mm (12 inches), which corresponds to a high level of juvenile recruitment (2014 cohort year class) reported by the ASMFC Striped Bass Technical Committee.

American Eel – The American Eel passage count at Holyoke Dam, which uses four specially designed ramp/traps in different project locations, was 38,449 in 2016, for the period May 17 through November 15, 2016. This is the third highest value for the 2003-2016 data time series, and a substantial increase from the 20,038 total in 2015 (Figure 7). A new eel ramp/trap was completed and operational for most of 2016 on the South Hadley side of the dam. The Holyoke Gas and Electric Report on American Eel passage will be available in the winter of 2017 and will compare catch rates among the trap locations and provide details on other statistics. American eels captured in these ramp/traps are relatively small in size. In 2015 it was reported 87% of the trap catches ranged between 10-20 cm in total length. American Eel trap/passage count data from Holyoke Dam for 2016 in relation to mean daily river discharge is shown in Figure 8. The Rainbow Dam blind eel pass captured 828 American Eel that were passed upstream of that dam. This number is intermediate to previous years' data: 689 (2015); 1,905 (2014); 910 (2013); 197 (2012); and 5,512 (2011). Data for the new American Eel pass at the Westfield River, West Springfield Fishway were not available at the time of the report.

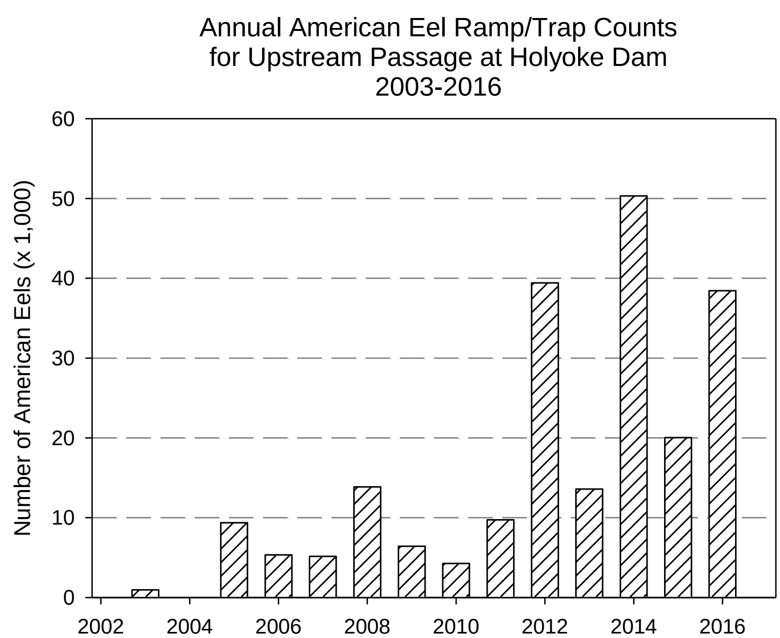


Figure 7. Annual American Eel ramp/trap counts reported by Holyoke Gas and Electric, at Holyoke Dam, for the period 2003-2016.

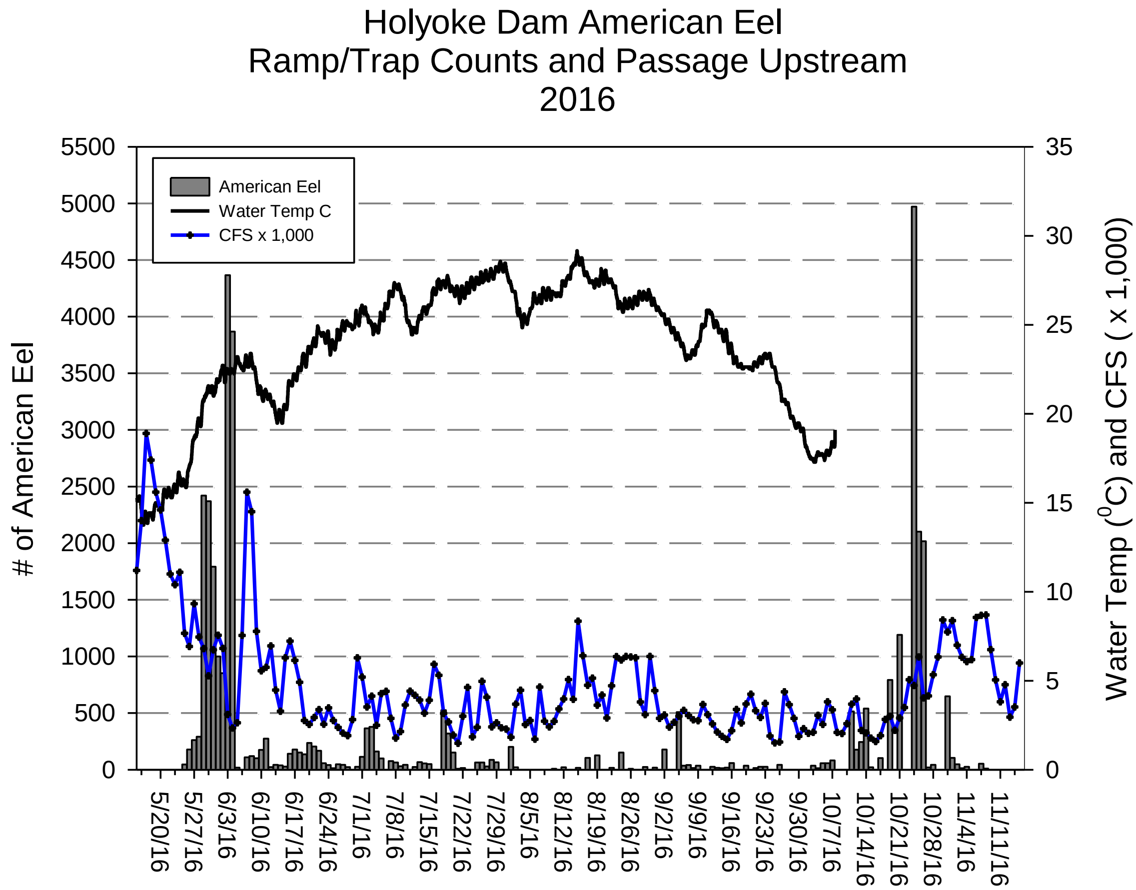


Figure 8. American Eel daily counts from eel passes/traps at Holyoke Dam plotted with daily mean river discharge from USGS Holyoke gage and USFWS temperature data.

<u>Atlantic Salmon</u> - A total of five sea-run adult Atlantic Salmon were documented as returned to the Connecticut River basin during 2016. This is a decrease from the 22 known adults that returned in 2015 (Figure 4). Starting in the lower basin, one adult was captured downstream of the Leesville Dam, on the Salmon River (CT) and was released into upstream habitat. One adult salmon was captured at the West Springfield Ladder on the Westfield River (MA) and was trucked upstream of existing dams without passage into suitable spawning habitat. The remaining three adult salmon were captured at Holyoke Fish Lift and all were retained for swimming performance research at the USGS CAFRC for a period of less than 48 hours, after which they were released immediately downstream of the CAFRC.

Juvenile Atlantic Salmon Releases - Connecticut

A total of 66,009 Atlantic Salmon fry were stocked in the Salmon River basin (22,702) and Farmington River basin (41,307) in 2016. This is a substantial decrease from the 390,667 fry stocked solely in the State of Connecticut in 2015.

<u>Gizzard Shad</u> - A total of 598 Gizzard Shad were counted at the Holyoke Fish Lift in 2016, an increase from the 84 passed in 2015 and the 410 passed in 2014.

Fish Passage

There has been a diversity of activities related to fish passage, some of which are highlighted in this section. John Warner continued in his role as the USFWS Hydropower Coordinator in this basin. In this report period, the CRASC continued to not have FirstLight Power install their smolt barrier net at Northfield Mountain Pump Storage facility. Fishway inspections prior to the start of the 2016 season, or early in the season, were completed by USFWS Fish Passage Engineers Brett Towler and Brian Waz (Vernon, Turners Falls, Holyoke, and on Westfield River -West Springfield Dam). These annual inspections have identified issues that were brought to the attention of the operators and have been resolved in a timely manner.

At Holyoke Dam, Holyoke Gas and Electric completed the new downstream fish passage measures that were operational for the first time in April 2016. These measures included reduced full depth, bar rack spacing in front of the station intakes, deep/submerged downstream fishway entrances (two entrances built in the new rack), and a new hydraulic jump for bascule gate discharge, over the spillway fishway entrance into an excavated plunge pool, all of which were designed to improve downstream passage protections for Shortnose Sturgeon, American Eel, and American Shad. This significant project also included alteration to the spillway fishway entrance to make it better suited for entry by Shortnose Sturgeon, as well as improving the entrance attraction jet (water flow), under the bascule gates discharge that is directed into the air at the dam apron and into a designed/excavated plunge pool ~10 meters away. A small retaining wall that had previously interfered with the bascule gate's discharge off the spillway fishway entrance was also removed.

Study plans to evaluate upstream American Shad passage with the new spillway entrance configuration were designed and executed in 2016. Study results have not yet been received by the agencies for that work. Studies to evaluate downstream passage of adult out-migrating silver American Eels and also for juvenile American Shad were also conducted in the fall of 2016, with no reports available at this time. As mentioned earlier, studies to evaluate fish passage, both up and downstream for Shortnose Sturgeon were not designed and conducted in 2016 as was hoped. However, the study design necessary for this species are expected to be developed and implemented in 2017.

The Turners Falls Dam and Northfield Mountain Pump Storage, with their ongoing FERC relicensing studies, had many study reports submitted to FERC in 2016. The agencies benefitted from a large inter-agency effort to review these reports and develop response/comment letters. Study response letters identified any areas of concern with design, sample sizes, analyses, results and interpretation that were also discussed at meetings and in other venues. The agencies currently have yet to receive reports that include instream flow/habitat, NMPS entrainment (repeated in 2016), and downstream juvenile American Shad.

Vernon, Bellows Falls, and Wilder Dam projects, as part of their relicensings also had many study reports submitted to FERC in 2016. These reports required a large inter-agency effort to review and comment on relative to study goals and objectives. Study response letters identified any areas of concern with design, sample sizes, analyses, results and interpretation that were also discussed at meetings.

Appendix A. Fishway count report produced by CTRFWCO for distribution and posted on office web site.

2016 Connecticut River Basin Fishway Passage Counts

Report Date: 12/30/2016

This report is compiled by the U.S. Fish and Wildlife Service, using fishway count data provided by several agencies as well power companies and is dependent in many cases on the review of video counts, that have an associated time lag for updates. Please visit http://www.fws.gov/r5crc for other count data summaries, and related information.

Fishway, River	***Data as of:***	**American shad**	**Alewife**	**Blueback Herring**	**Atlantic Salmon**	**American Eel**	**Sea Lamprey**	**Striped bass**	**Gizzard Shad**	**Shortnose Sturgeon**	**Other**
Mary Steube, Mill	final		406								
Moulson Pond, Eightmile	final	10	83	3,421			40				
Leesville, Salmon	final				1[A]		669[B]				
StanChem, Mattabesset	final	36	303				13		87		
Rainbow, Farmington	final	141				828[C]	494				
W. Springfield, Westfield	final	5,940			1		449				
Holyoke, Connecticut-MA		385,930		137	3	38,449[C]	35,249	638	598	**94[D]**	
Easthampton, Manhan	final						59				
Turners Falls, Connecticut-MA	in review	54,069					15,128				
Vernon, Connecticut-VT	final	35,513				-907	5,521				
Bellows Falls, Connecticut-VT	final	1,973				-163	1,619				
Wilder, Connecticut-VT	not run										
*Total to basin, only **first** barrier counts*		392,057	792	3,558	5		36,245	638	685	79	
Last year totals		416,355	237	11,822	22		24,573	21	84	1	

All returning adult sea-run salmon will be streamer tagged below its dorsal fin and released and if angled released without harm, preferably without removing from the water. Please contact USFWS at 413-548-9138 x8121 to report any capture/releases.

[A] adult Atlantic Salmon captured downstream of Leesville moved/released upstream

[B] Count is based on nest surveys

[C] special ramp/traps

[D] Shortnose Sturgeon captured at lift were returned back downstream, 15 recaptured twice, 4 recaptured 3 times

Appendix B. The Connecticut Marine Fisheries Division's Juvenile Alosine Seine Survey data of annual catch rate values, provided to the Atlantic States Marine Fisheries Commission. Values are geometric mean catch rates from seine surveys conducted at seven sites from July through November annually.

Year	Juv Shad	Juv BBH
1978	5.89	
1979	7.84	24.8
1980	9.21	26.75
1981	6.05	11.49
1982	1.81	6.09
1983	4.99	16.47
1984	3.37	11.57
1985	7.14	18.23
1986	6.29	13.61
1987	9.89	21.58
1988	5.68	17.04
1989	4.85	7.52
1990	10.39	14.41
1991	3.92	11.36
1992	7.21	9.87
1993	9.49	14.43
1994	12.22	13.92
1995	1.34	5.03
1996	6.5	5.91
1997	6.75	9.66
1998	3.65	4.39
1999	5.47	5.57
2000	4.42	4.17
2001	2.73	3.83
2002	5.55	3.95
2003	6.88	5.88
2004	5.62	2.36
2005	10.08	4.10
2006	1.82	3.50
2007	8.15	6.61
2008	5.06	2.20
2009	3.4	1.77
2010	10.23	12.82
2011	3.08	2.93
2012	3.03	2.22
2013	3.16	6.89
2014	8.03	3.69
2015	8.53	8.63

Appendix C. History of the Anadromous Fish Program

Native diadromous fishes (diadromy includes anadromous and catadromous fishes, with American Eel being the only catadromous species in this basin) were once abundant in the Connecticut River basin excluded from habitat only by natural barriers and their physiological limitations. Atlantic Salmon ascended the main stem Connecticut River to Beechers Falls, VT, nearly 400 miles upriver from its outlet at Long Island Sound. American Eel have been documented even farther upstream in the basin by early New Hampshire Fish Game studies. No fishery management or scientific information exists that provides a technical description of the pre-colonial diadromous fish populations. However, historical accounts of the region are filled with references to large American Shad, river herring and Atlantic Salmon runs which were known to have been an important food source in the spring for the native people and early European settlers. As colonization by Europeans and the development of water power sites expanded throughout the basin, anadromous fish populations notably declined. A major cause of the declines or loss of runs was largely the construction of dams that blocked fish migrations from reaching their spawning habitat (Figure 1). Tributaries were more easily dammed and so elimination of these species progressed rapidly in these areas first, with settlement and use of early water power for mills. The first dam across the main stem Connecticut River was constructed as early as 1798, for barge/boat movement, near the present site of Turners Falls, MA. This dam blocked returning American Shad, river herring, Atlantic salmon and Sea Lamprey from access to spawning habitat in the northern and central portion of the river basin. As a result, those species simply disappeared from both New Hampshire and Vermont.

An interagency state/federal program to restore salmon to the Connecticut River based on the stocking of fry hatched from eggs taken from Penobscot River Atlantic Salmon was initiated in the 1860s, decades after the construction of the Holyoke Dam, MA. Although the effort resulted in the return of hundreds of adult salmon for several years in the 1870s and 1880s, the program eventually failed due to both uncontrolled harvest of fish in Connecticut waters and the failure to construct effective fish passage at dams in Massachusetts. Concurrent with the salmon restoration effort were the state's American Shad culture and stocking efforts to enhance reduced runs of this valued species. Work to restore and enhance these two species was conducted through developing fish culture techniques that were gaining popularity as an approach to achieve fishery management goals.

Although interest continued in restoring Atlantic Salmon to the basin, no action was taken for many decades due to the lack of funds and the lack of effective fish passage technology (an early design fish ladder had been installed at Holyoke Dam). The condition of the river environment continued to deteriorate in response to widespread pollution and dam construction through the early to mid-1900s. By the 1960s, some tributary dams were breached and pollution abatement programs were initiated. Long term cooperative restoration programs became feasible with the passage of the federal Anadromous Fish Conservation Act of 1965 (P.L. 89-304) which made funds available for interstate fish restoration programs. The combined effects of these events set the stage for anadromous species restoration. In 1967 the four basin states, USFWS, and NMFS signed a statement of intent to restore anadromous fishes including American Shad, Atlantic Salmon, and river herring to the Connecticut River. Atlantic Salmon were a focus due to its appeal for recreational angling opportunities by the resource agencies. Early salmon stockings were initially comprised of two-year old smolts of Canadian origin reared in federal trout hatcheries that had recently been converted to salmon production. The term smolt defines a salmon life-stage when the transitional migration from freshwater to the marine environment occurs, typically in the months of April and May. The first adult salmon return from these smolt releases was documented in 1974.

Early in the Atlantic Salmon Program the management emphasis was placed on stocking smolts with the USFWS building a salmon hatchery in Bethel, VT, and CTDEEP and MADFW converting trout hatcheries for salmon production. Production of stream-reared smolts, from juvenile stockings, was combined with smolts produced in hatcheries to increase smolt emigration from the river. A major effort was begun in 1987 to stock fry into appropriate habitat in the basin, based upon in-river research results.

Beginning in 1994, the Program utilized only "Connecticut River" fish, with no introductions of genetic material from outside the basin. Genetic monitoring had demonstrated the development of some unique genetic characteristics (alleles) that distinguish the Connecticut River population from other populations at that scale. The use of conservation genetics enabled the Program to maintain a genetically healthy population to maximize genetic diversity and reduce risks from genetic issues.

Adult Salmon returns per 10,000 stocked fry declined dramatically from what had been documented from 1979 through 1994, when this rate averaged 0.71 (high of 1.6). For the period 1995 through 2008, the mean adult/10,000 fry stocked was 0.11 (refer to U.S. Atlantic Salmon Assessment Committee Report 27 – 2014 Activities (http://www.nefsc.noaa.gov/USASAC/Reports/). This latter period is when the program shifted to fry stocking as the primary restoration strategy, coinciding with this unexpected decline in fry return rates (due to marine survival rate decreases). This situation translated to a sustained reduction on the order of 1/6 of what had been observed for this rate (< 1994) even as issues of safe downstream passage of smolts at hydropower facilities and ocean fishery closures were completed. Studies over time have shown shifts in salmon marine prey species abundance and distributions, shifts in predator assemblages, and shifts in marine habitat area use are likely contributing factors that can be related to climate change.

The severe damage to the White River National Fish Hatchery (WRNFH) in fall of 2011, from a flood event, severely impacted the Salmon Program as it maintained a high proportion of the domestic broodstock and subsequently annual egg and fry production for all the states. WRNFH had been producing approximately 65% of the fry for the Program in the preceding 10 years. The loss of this facility, in conjunction with ongoing reviews of the best science and information related to restoration efforts, and emerging USFWS Northeast Region fisheries issues and priorities, led the USFWS to announce its decision to conclude fish culture activities for the Connecticut River Atlantic Salmon Program. That announcement was made in public at the July 2012 Connecticut River Atlantic Salmon Commission meeting. Subsequently, in the fall of 2012, the Commonwealth of Massachusetts decided it would no longer culture salmon at its Roger Reed State Hatchery. The last spawning of domestic salmon broodstock occurred at that facility in 2012, with all fry and remaining Connecticut River salmon of various ages stocked out in 2013. The State of New Hampshire had concluded the restoration effort with a last stocking in 2012 while the final stocking in Vermont was in 2013.

The State of Connecticut currently operates a "Salmon Legacy Program," which is not a restoration program but serves other defined purposes. The goal of Connecticut's program is to maintain Atlantic salmon in select watersheds, maintain existing genetics of the Connecticut River salmon, provide fish for their state broodstock fishery program (outside of the Connecticut

River basin), and support educational programs such as the school egg/fry rearing program.

Action to provide upstream fish passage on the Connecticut River main stem in the mid-1900s occurred in 1955, when a rudimentary fish lift was constructed at Holyoke Dam to pass American Shad and river herring, that relied on humans pushing them in wheeled buckets. At that time, and for approximately three decades after, the Enfield Dam remained a partial barrier, even though laddered, eventually disintegrating completely in the 1980s. The Holyoke Dam facility was expanded in 1976 when substantial upstream passage modifications occurred, with a new second lift installed in the spillway (or at the base of the dam, as opposed to the existing "tailrace" lift entrance). Although not studied, upstream passage efficiency appeared to improve greatly with corresponding increases in annual fish counts for species like American Shad and Blueback Herring (Figure 7). Other fishways built at dams on the main stem river and tributaries allowed returning Atlantic Salmon, American Shad, river herring, and Sea Lamprey access into select portions of the basin (with varying degrees of fishway effectiveness) targeted for restoration. Major issues with several different fishways have been apparent relative to ineffectiveness at passing American Shad and river herring. These issues have been dealt with on a case by case basis, with varied degrees, of success. However, with the Federal Energy Regulatory Commission's five main stem project relicensing underway (through 2018 and beyond), opportunities for improvements for fish passage are anticipated along with plans to address other problem sites in the near future (e.g., Rainbow Fishway on the Farmington River).

Upstream passage at Turners Falls Dam (Massachusetts) fishways (first operational in 1980) have been studied and modified for decades and is one of the projects in the FERC relicensing process at this time. Passage issues relative to American Shad are best explained by the fact that no ladders of the size required on the main stem had been designed for that species as the cooperative restoration effort took this management need on in the 1970s. The USFWS relied on the best information (no specific studies available) at the time that suggested West Coast fish ladders on the Columbia River were effective at passing American Shad. This led to the adoption of these designs, downsized considerably from the Columbia River, for use on the main stem dams. The USFWS worked with the power companies in the design and construction, to develop operating parameters for flow, velocities, and turbulence measures. However, the down scaling created some unforeseen challenges in hydraulics for these species that the agencies, researchers (USGS CAFRC), and power company consultants have worked on resolving over the years.

Following on the Turners Falls ladders completions, the Vernon Dam (Vermont) fish ladder became operational in 1981 with Bellows Falls and Wilder dam fish ladders in the subsequent years. As the number of salmon fry stocked in the basin increased during the late 1980s, concern grew for the potential negative effects of hydroelectric turbines or other passage routes on outmigrating smolts, as well as juvenile and post spawn adult American Shad. Efforts to provide safe and effective downstream fish passage on both main stem and tributary projects were initiated in the 1980s. In 1990, a memorandum of agreement (MOA) were signed with two major utility companies that operated hydroelectric facilities at six main stem projects that established time frames for downstream fish passage construction.

Efforts to provide necessary fish (all diadromous species) passage conditions at these projects and throughout the basin are ongoing. A recent example is Holyoke Dam and its new downstream passage facilities, designed specifically to address adult American Eel and Shortnose Sturgeon that became operational in 2016.

The state and federal agencies continue to work in close cooperation with many partners to address fish management, protection, enhancement, and restoration topics for both populations and habitats. This work is important for the ecological, recreational, and commercial benefits, derived from healthy native fish populations and the aquatic habitats they require. Currently, ongoing fisheries work includes continuing efforts to increase both abundance levels and distributions (particularly upper basin and in tributaries) as well as stock structure characteristics (multiple age classes and repeat spawners) to support population resilience and health. The current FERC relicensing process for the five main stem facilities is important in this regard relative to the 30 or more year length of these federal licenses. The final license conditions for these commercial operators may serve to protect, mitigate and enhance the public's fishery resources. The CRASC and its predecessor, the Connecticut River Policy Committee, have provided and continue to provide, a critical coordinated fishery leadership role from policy setting to project implementation, resulting in many positive outcomes not observed in other large East Coast river basins.